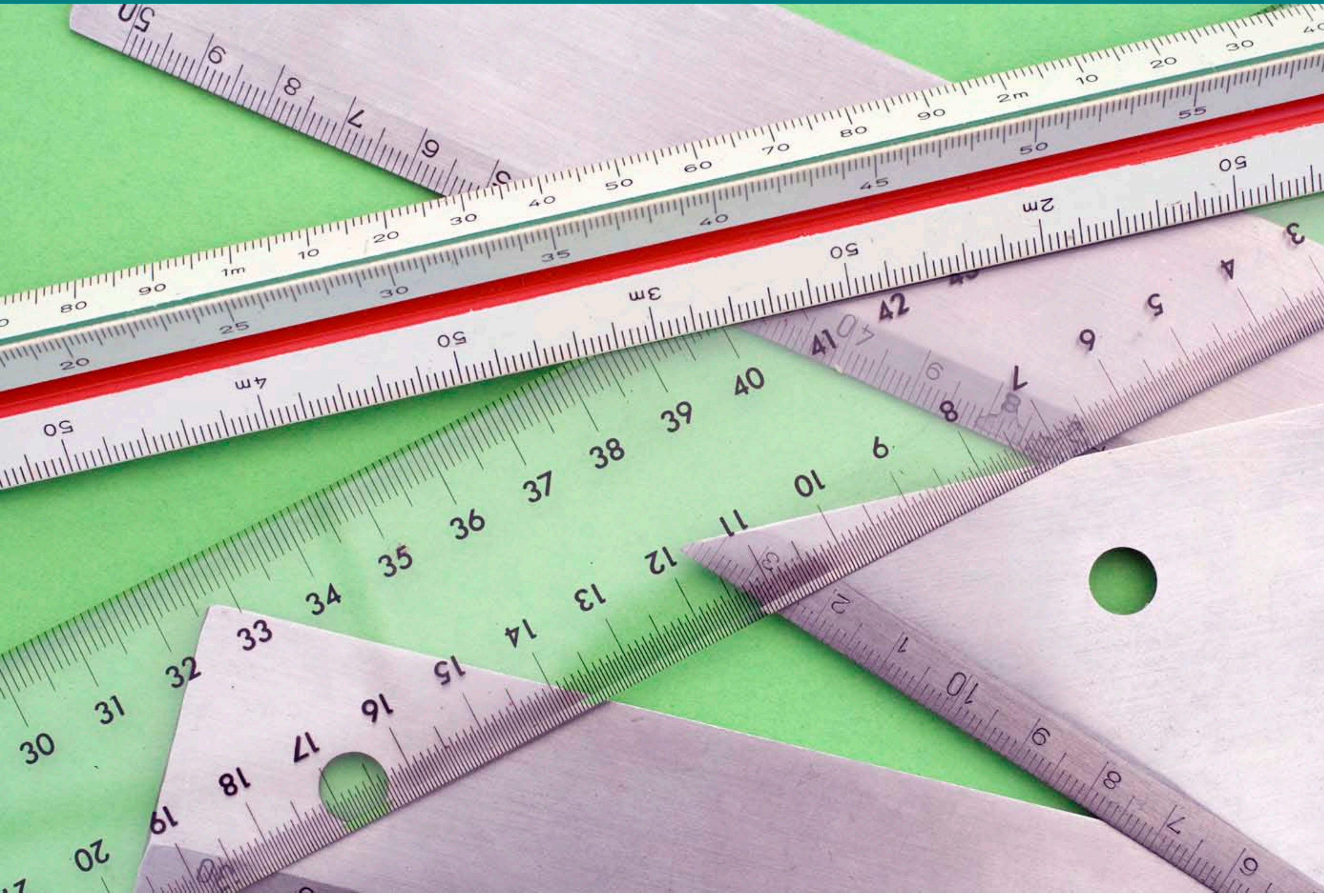
Measuring and Reporting Progress in Reducing GHG Emissions



Climate Mitigation for Local Governments Milestone Five

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Statewide Energy Efficiency Collaborative

An Alliance to Support Local Government

This **Measuring and Reporting Progress in Emissions Reduction** instruction document is a product of the **Statewide Energy Efficiency Collaborative** (SEEC). SEEC is a new alliance to help cities and counties reduce greenhouse gas emissions and save energy. SEEC is a collaboration between three statewide non-profit organizations and California's four Investor Owned Utilities.

SEEC members are:

- ICLEI – Local Governments for Sustainability USA
- Institute for Local Government
- Local Government Commission
- Pacific Gas and Electric Company
- San Diego Gas and Electric Company
- Southern California Edison Company
- Southern California Gas Company

SEEC provides education and tools for climate action planning, venues for peer-to-peer networking, technical assistance and recognition for local agencies that reduce greenhouse gas emissions and energy use.

The collaborative effort is designed to build upon the unique resources, expertise and local agency relationships of each non-profit organization, as well as those of the four investor owned utilities.

The program is funded by California utility ratepayers and administered by Pacific Gas and Electric Company, San Diego Gas and Electric Company, Southern California Edison, and Southern California Gas Company under the auspices of the California Public Utilities Commission.

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Introduction

Why Measure and Report Progress?

It has been said that you "can't manage what you can't measure," and this is particularly true in regard to climate planning, as climate action plans estimate the projected impact of a set of measures, but require performance tracking over time to determine the actual impact of local climate mitigation activities. Local governments make decisions every day that reduce GHG emissions – from decisions about land use patterns to allocating funding for retrofit programs. Measuring and tracking the actual impact of implemented actions is important because it not only allows a local government to better understand the progress that it is making towards its GHG reduction goals, but because it also can help a local government target future investments in effective, high-impact strategies.

Measuring and reporting progress are important parts of Milestones 4 and 5 in ICLEI's Five Milestones for Climate Mitigation. The Milestones provide a framework and methodology for local governments to identify and reduce greenhouse gas emissions:

1. Conduct an inventory and forecast of local greenhouse gas emissions;
2. Establish a greenhouse gas emissions reduction target;
3. Develop a climate action plan for achieving the emissions reduction target;
4. Implement the climate action plan; and,
5. Monitor and report on progress.

Measuring to Understand Impact and Refine Strategies

To ensure that climate action plans are implemented effectively and on schedule, it is important to develop systems and processes to monitor implementation, measure results over time, track changing conditions, leverage new information and ideas, and revise targets and plans as needed.

Careful tracking of progress is important to determine if GHG emissions are changing in the way they were predicted to change. If emissions reductions targets are not being met, staff can evaluate the reasons why and respond appropriately. Additionally, GHG emissions are increasing nationally due to factors like population and economic growth, so even when overall emissions increase, local governments still may be reducing the GHG emissions from what would occur under a "Business As Usual" scenario if no actions were taken. Tracking the impact of discrete measures will demonstrate the impact that local governments are having and can better position local governments to make even deeper reductions over time.

Measuring to Target Investments and Access Funding Streams
Tracking the impact of individual measures will help local governments identify the best practice measures that not only provide GHG reduction value, but also deliver the best return on investment. By tracking the impact of individual measures, local governments can understand the most effective ways to use scarce resources and can also understand how to effectively target future investments in GHG mitigation efforts.

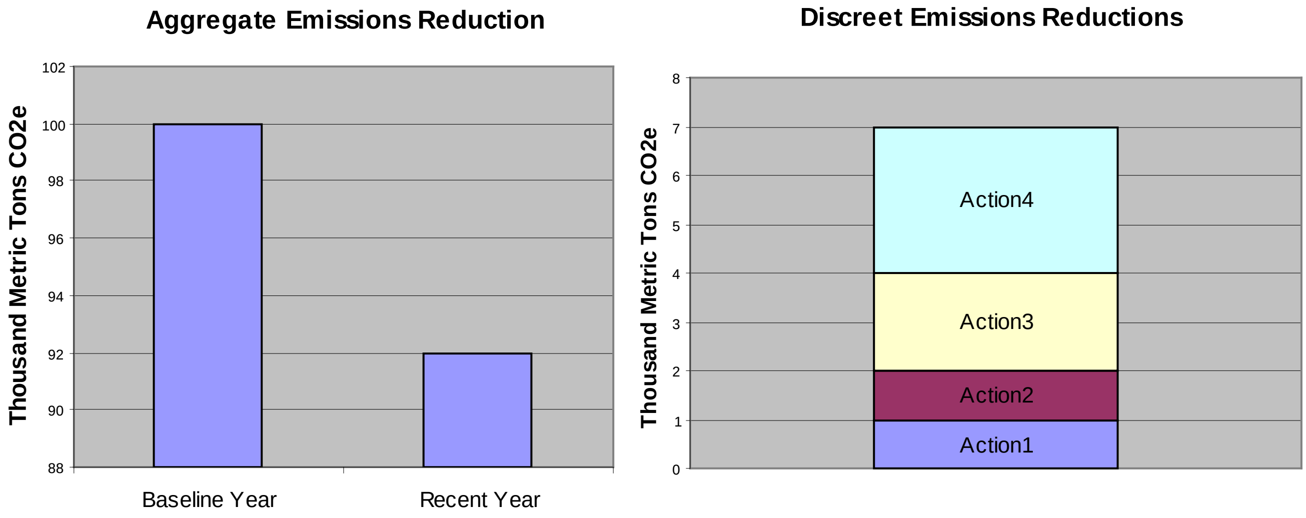
Local governments with effective methods for tracking the impact of their strategies will also be better positioned to access federal and private funding sources; communities with proven track records of success are better candidates for investment and also can meet the criteria for performance tracking that is often associated with grant funding.

Measuring to Demonstrate Tangible Impacts and Showcase Success
Tracking and measuring success should be done routinely so that local government staff can demonstrate the progress that is being made towards reaching GHG reduction targets. Publicizing the achieved emissions reductions are also a great way to rally support and should be accompanied with announcements of new initiatives that will take the community further towards its next goal.

Overview of the Measuring and Reporting Process

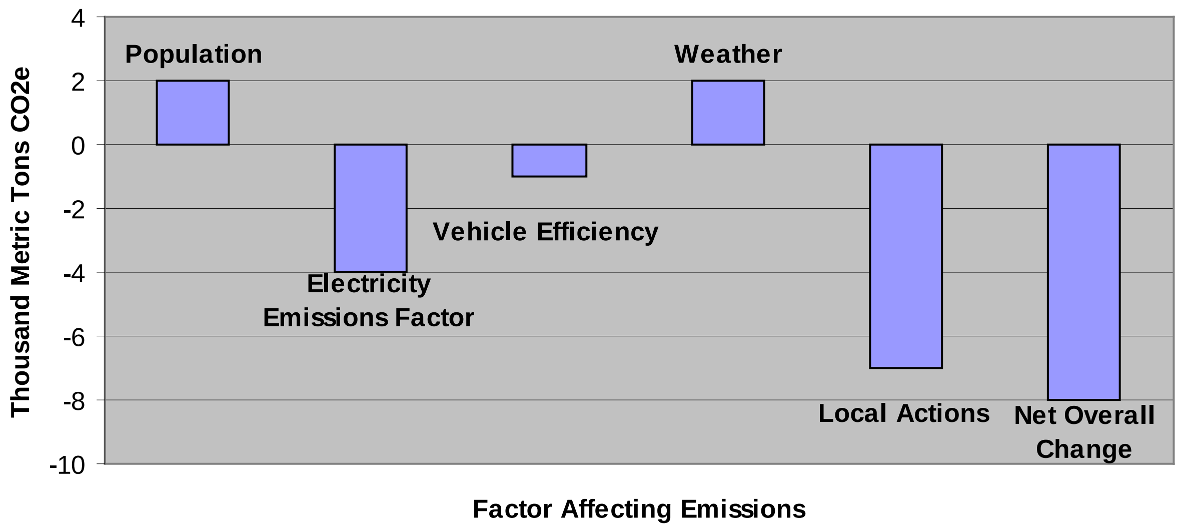
There are two basic ways that a local government can show progress towards reducing GHG emissions and more efficient local government services: updating the **aggregate** baseline inventory and estimating **discrete** outcomes from individual projects Aggregate measurement though a periodic re-inventory of emissions gives an overall picture of how the many sources of greenhouse gases are changing over time. Accompanied by the appropriate indicators, these shed light on the processes that are outside of the control of the local government and can bring a clearer picture of the challenge of reducing emissions into focus. Discrete, project-based measurement demonstrates tangible individual successes and can build momentum for continued mitigation efforts. ICLEI recommends that local governments pursue both approaches when feasible to support a successful climate mitigation initiative.

Figure 1: Example of Aggregate and Discrete Emissions Reductions



A hypothetical example of aggregate and discrete emissions reductions is illustrated in Figure 1. In this example overall emissions decreased by 8,000 metric tons CO2e, and the reductions calculated for individual actions add up to 7,000 metric tons CO2e. However, there are other factors that affect the overall emissions besides the specific local actions taken, as illustrated in Figure 2. Here, population growth, changes in electricity generation and vehicle efficiency, and the weather both add to and subtract from overall emissions, leading to a net decrease of 1,000 metric tons CO2e in the absence of local actions, and the observed net decrease of 8,000 metric tons CO2e when combined with local actions. Section 3 of this document has guidance on understanding the influence of external factors on changes in emissions.

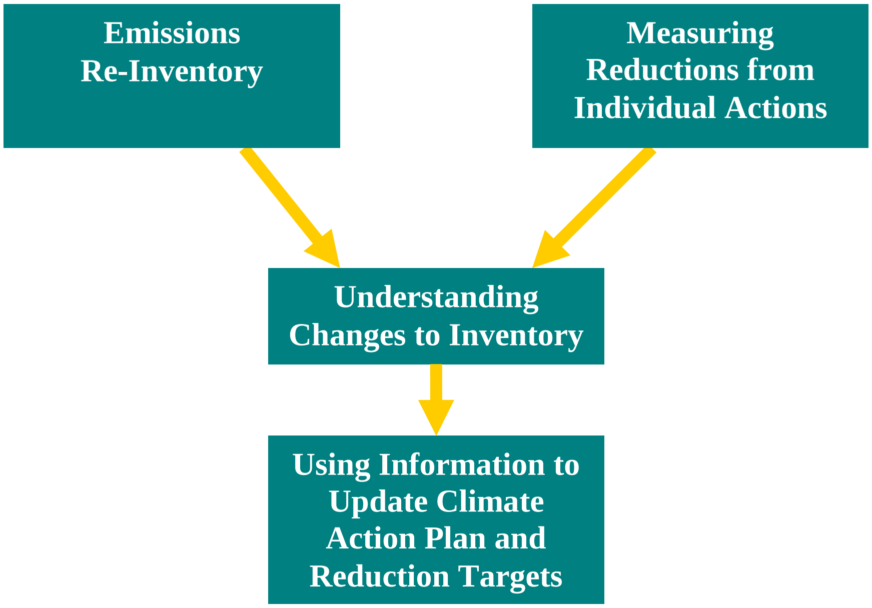
Figure 2: Factors Affecting Emissions



Be aware that Figure 2 represents an idealized hypothetical example. It is very unlikely that you will be able to calculate the effect of every external factor, or the effect of all emissions reduction projects, with precision. As a result, you will not see all the factors add up to the exact difference between your baseline and re-inventory. Rather you will need to use the information from your re-inventory, the analysis of external factors, and the estimated reductions from your individual measures all together in order to form the most useful picture of how emissions are changing and to guide policy. Both the overall and discrete approaches work together, allowing local governments to understand both the aggregate impact of the portfolio of emissions reductions efforts that a community is undertaking and the efficacy of discrete, individual actions so that they can be modified, as needed. In some cases, resources may only be available to perform the re-inventory; while ICLEI recommends doing both the aggregate re-inventory and the discrete project-based analysis, the re-inventory may be the more informative of the two and may be prioritized when seeking to measure and report progress.

This guide is divided into four sections. The first two sections cover the two ways of measuring emissions reductions; the re-inventory to measure overall emissions reductions, and measurement of reductions associated with individual projects. Section 3 describes how to account for the various factors responsible for the overall change in emissions. Finally, Section 4 covers using this information in a re-evaluation of your Climate Action Plan and, if necessary, your emissions reduction targets. This process can be visualized as in Figure 3.

Figure 3: Steps in the Progress Measuring and Reporting Process



1. Conducting an Emissions Re-inventory

The emissions re-inventory is currently the most effective tool for evaluating overall progress towards your emissions reduction goals. The process of conducting an emissions re-inventory is in most ways just like conducting the original baseline inventory. The additional piece to consider is that you will want to make sure your methods are the same between the baseline and re-inventory. In some cases you will have better methods or data availability for the re-inventory, and will want to do a baseline update, changing the baseline to the new method so that it can be compared with the re-inventory.

Steps in conducting re-inventory

1. Read instructions on inventory data collection for government operations and community (if your original inventory and action plan cover both).
2. Review the previously conducted inventory.
3. Collect data for new inventory.
4. Make baseline adjustments as needed.
5. Perform inventory calculations in ICLEI's CACP software or a similar tool.

Reviewing the Previous Inventory

Review the baseline inventory before starting data collection for your new inventory, so you are aware of the previous methodology used, and where any baseline updates might be needed. In reviewing the baseline inventory, look for:

- Which sectors were included. If you want include a sector in the new inventory that was not included in the previous inventory, you will need to either do a back-cast for that sector for the previous inventory year, or exclude that sector from the new inventory when comparing the two.
- Any notes about calculation methodologies. Be sure to use the same method as the baseline inventory whenever possible.
- The contacts who provided data. Having these can save time in finding the right contact for a re-inventory. Also, going back to the same contact, where possible, will make it more likely you'll get data provided in the same way.
- Situations where the inventory boundaries may have changed between the baseline year and now. An example with a community inventory would be annexation of additional land within the jurisdictional boundary. An example with a government operations inventory would be if a service that was previously contracted out is brought in-house. In both these cases, emissions from these areas occurred in both the baseline year and the more recent year, but the emissions moved from outside the inventory boundary to inside. These situations should be addressed by a baseline adjustment, adding data on the new area (or an estimate or back-cast if necessary) to the baseline inventory. Conversely, if there was a service provided in-house in the baseline year that is now contracted out, it is recommended to obtain data from the contractor to continue to include that sector as Scope 3 emissions in the new inventory.

Changes in Emission Calculation Methodologies

It should be recognized that methodologies for calculating GHG emissions at the community scale are constantly evolving. For example, emissions from the transportation sector can be calculated using several methods (e.g. fuel-based methods or VMT based methods). Similarly, emission calculation methodologies in the waste sector can be very different depending on whether they include lifecycle emissions or not. As these methods become more refined, local governments may be encouraged to use these new methods for better accuracy of emission calculations. Under such circumstances, it is important that local governments make necessary revisions to their baseline inventories such that it enables an apples-to-apples comparison between the baseline and subsequent inventories.

Making Baseline Adjustments

There are two types of baseline adjustments you might make: adjustments to fill in missing data or sectors, and updates to emissions factors.

If your original inventory was conducted using CACP 2003, you will need to update the emissions factors to be consistent with the Local Government Operations Protocol and CACP 2009. The recommended way to do this is to transfer all data to CACP 2009. In many cases an intern can accomplish data transfer in just a few hours. For members with large amounts of data in the original CACP, ICLEI staff can provide guidance on exporting your data into excel and re-importing it into CACP 2009.

For baseline adjustments where you are adding a sector or emissions source not originally included, you should try to obtain activity data on that source for the baseline year. In some cases, it is not possible to get data as far back as the baseline year and you will need to do a back-cast. You can back-cast using the same indicators used in forecasting. Suggested indicators by sector are listed in Table 1.

Table 1: Indicators for Back-casting/Forecasting by Sector

Sector	Indicators
Residential	number of households, population
Commercial	commercial sq. ft, commercial jobs
Transportation	population
Waste	population

Perform Inventory Calculations

Performing the calculations for the re-inventory is much the same as performing calculations for a baseline inventory. CACP 2009 or a similar inventory software tool will be helpful in performing these calculations.

If using CACP 2009, before you begin entering data, download the latest version or patch of from www.icleiusa.org. If you have previous inventory data in CACP 2009, a patch will leave that data intact, while updating all default emissions factors (any custom emissions factors you have created will not be changed).

You can switch between years in CACP using the ‘Year’ menu. It is a good idea to first save the current inventory year. Then select Year-> Open. You will be prompted again to save the current year; for safety select yes. Now a box will open to allow you to choose a new year. Years that currently have data will appear on the right, while all available years will appear on the left.

You can also use the Year-> Save As function. This will copy all the current year data to another year. This can be useful for copying all the record names. If you do this, go through each record and set all activity data to zero before you start entering new data; this way you won’t accidentally leave prior data in.

Caution: be sure to save the current year before using save as to copy data to another year.

2. Evaluating Emissions Reductions from Individual Projects

This section provides guidance on how to measure emissions reductions achieved by discrete climate action plan measures that have been implemented. This analysis can be utilized in concert with the aggregate re-inventory to best measure progress. In some cases, resources may only be available to perform the re-inventory; while ICLEI recommends doing both the aggregate re-inventory and the discrete project-based analysis, the re-inventory may be the more informative of the two and may be prioritized when seeking to measure and report progress.

General Methodology for Reductions

In general, when determining the emissions reductions resulting from an action, we are comparing the actual emissions that occur after implementation with a reference case of what would have happened without the action. The actual emissions in most cases can be calculated based on real-world data, but the reference case presents a more difficult challenge in estimating emissions. Sometimes, measurements of the system (for example, a building or group of vehicles) before the action can be used, with correction made for changes other than the action being evaluated. In other cases, the reference case is completely hypothetical and must be based on averaged data or equipment specifications.

Often, more specific data is available for actions affecting government operations than for those affecting the community, so methods for the two are treated separately in the following sections. Planning for quantification of emissions at the beginning of implementation can make obtaining the needed data much easier; guidance on what to consider is included at the end of this section.

Reduced and Avoided Emissions
It is important to understand the conceptual difference between reduced emissions and avoided emissions. Reduced emissions come from actions that affect emissions sources included in the baseline. An example would be energy efficiency retrofits to an existing building. Avoided emissions come from actions that make a new emissions source smaller than it otherwise would be. An example would be building a new building with beyond-code efficiency measures. Both reduced and avoided emissions help you close the gap between the business-as-usual emissions trajectory and your goal. However, avoided emissions alone cannot reduce emissions below your baseline. There is also a difference in how reduced and avoided emissions are measured. With reduced emissions you can compare activity data after the action with that from before (though corrections for weather, building occupancy, and other factors may be needed). With reduced emissions, you must compare with a hypothetical case.

Electricity Emissions Factors to Use in Reduction Calculations
Emissions reductions are calculated by multiplying a change in activity data by an emissions factor. For reductions in electricity usage, the emissions factor of CO2e/kWh varies throughout the day and year as different generating units are brought online or shut down to respond to demand. Some estimates of emissions reductions use marginal emission factors, accounting for the particular generating units displaced by reduced demand at a particular time. However, this takes considerable effort to do effectively.

ICLEI recommends using the most recent grid average electricity emissions factors for calculating emissions reductions from energy efficiency or renewable energy. Grid average emissions factors are calculated by adding the total emissions from electricity generation supplied to a region (which can be a utility service territory, a state, or a larger region) over the course of a year and dividing by all the kWh supplied to that region over the same period. Greenhouse gas emissions inventories are calculated from annual totals for electricity usage, and thus use the grid average emissions factors. Using grid average factors for emissions reductions as well maintains comparability between aggregate emissions changes measured through the inventory and emissions reductions calculated for individual measures.

Measuring Building Energy Reductions

The International Performance Measurement and Verification Protocol[1] (IPMVP) is the standard for measuring energy conservation in buildings. The IPMVP provides four evaluation method types, depending on the type of data you have and the level of rigor you are attempting. In most cases, options A, B, and D require the assistance of third party contractors and or careful pre-implementation planning to collect the necessary data to perform those analyses. However these options are not out of reach for all cases. The IPMVP contains guidance on setting up for assessment at the beginning of a project, and consumer off-the-shelf watt meters are making it possible to easily sub-meter certain plug loads from appliances and small equipment, giving local governments more options for those types of actions.

Because of typical data limitations, the rest of this section focuses on IPMVP Option C. In comparing the energy use of a building before and after implementation of conservation measure, there are a number of factors besides the measure itself that can cause changes. These include building occupancy, hours of operation, and the weather. To get the most accurate measurement we need to account for as many of these variables as possible, predicting what the energy use would have been in the absence of the conservation measure.

The most effective way to account for other variables is to eliminate them by attempting to measure data as close to the energy conservation measure as possible. In many cases this is not possible and we need to account for things such as changes in billing period length, days the building is open, hours open and occupancy by dividing out those variables. When examining the data you have available, think about what factors will influence that data and whether or not those are different in the before and after case. For example, if the occupancy of a building or hours of operation are essentially the same in both cases, dividing out those variables won't improve the reduction estimates. Also understanding what other types of equipment share the meter with the conservation measure will help you determine what variables need to be accounted for. If you have parking lot lights that are metered separately from the heating and air conditioning of a building, weather should not be a factor. On the other hand, if you have interior lighting that shares a meter with heating, air conditioning, or ventilation systems, metered energy use will be influenced by changes in the weather.

Correcting for (also known as normalizing for) weather is a two part process. The first is to establish the relationship that a building's energy use has with changes in the weather, using historical data from before an energy conservation measure was implemented. Once that is complete, you can use that relationship to estimate the reference case energy consumption that would have happened without the measure, over the same length of time. Generally this requires two full years of utility and weather data, one before and one after the measure was implemented. The difference between the reference case and actual post-implementation consumption are the savings.

[1] http://www.evo-world.org/index.php?option=com_content&view=article&id=272&Itemid=397&lang=en

Performing weather normalization for individual buildings without the help of specialized software can be complicated and highly technical process. Instructions for doing so are beyond the scope of this document. Correctly specifying all the parameters that go into the analysis will require familiarity with the building systems in question. The ability to interpret statistical outputs is also required, as well as a firm grasp of the potential sources of error that need to be controlled for. Many of these challenges can be overcome with the use of energy management software. Free options such as EPA's Portfolio Manager offer a low barrier to entry for this type of analysis.

Weather normalization at higher scales of aggregation, such as across an entire city, can be significantly easier. Dividing total annual energy consumption by total annual heating or cooling degree days can produce useful indicators that would give additional explanatory power to periodic greenhouse gas re-inventories and reveal trends in per capita energy consumption that may be otherwise obscured by changes in weather year to year.

Calculating Reductions in Buildings from Individual Equipment

One alternative if you do not have the data needed for the weather normalization described above is to calculate reductions based on the individual equipment changed. This method works well for equipment like lighting that is either on at a constant power level, or off. The basic equation for the energy usage of any piece of equipment is to multiply the instantaneous power load (usually measured in watts or Btu/hr) by the amount of time the equipment is on.

Energy use= power input (watts) x time on (hrs/year).

Upgrading equipment affects the power input variable, and the difference between the power use of the old and new equipment can be used to calculate the total energy reduction.

Equipment such as air conditioning compressors, refrigeration, and boilers or furnaces cycle on and off automatically and may operate at part-load (if equipped with variable speed motors). This makes the calculation a little more complicated. A use factor accounts for time when the equipment may be turned on by the user but is not operating because of automatic controls (for example, air conditioning controlled by a thermostat). If the equipment can operate at part-load, a load factor is introduced to account for this. Both the load factor and use factor range from zero to one. In most cases the load factor and use factor will need to be estimated, which is the weak point in using this equation. For heating and cooling equipment, the overall equation is:

Energy use = power ouput (watts or Bth/hr) x efficiency x time on (hrs/year) x load factor x use factor

Again the procedure is to establish a reference case to be compared with the conditions after a measure has been implemented. To do so through this type of estimation, we need to understand which of the variables in the equation above we are affecting through the measure and by how much. Calculating the difference between a reference case of the equation and the altered case will give us an estimate of the energy consumption we have reduced. Table 2 lists the variables affected by different kinds of energy efficiency measures; the degree to which these factors are changed depend on the nature of the exact measure.

Table 2: Variables Affected by Energy Efficiency Measures

Type of Measure	Variable affected
Efficiency or Equipment Sizing	Power
Timers and Other Controls	Time
Variable Speed Motors	Load Factor
Building Envelope	Use Factor

Calculating Vehicle Fleet-Related Reductions

The most common action for reducing emissions from government fleet vehicles is to replace existing vehicles with new ones that are more efficient. The method to calculate emissions reductions from this replacement is to use historical data on the vehicles replaced to calculate their fuel efficiency, measure the fuel used and miles traveled by the replacement vehicles, and then calculating the fuel that would have been used by the reference vehicle to travel those miles.

1. Use miles driven and fuel use data for the previous vehicles to calculate their real-world fuel-efficiency. This may vary significantly from the EPA 'sticker' miles-per-gallon. If the new vehicles are not replacing existing vehicles but instead replacing hypothetical vehicles that would have been purchased under business as usual, this real-world data will not be available. If there are existing vehicles in the fleet of the same model and that operate under the same conditions as the business as usual vehicles, these can be used as a proxy. If not, the EPA provided miles-per-gallon should be used.
2. Divide the miles that were actually driven by the new vehicles by the miles-per-gallon of the reference vehicle in order to calculate the gallons that would have been consumed under business as usual.
3. Compare this number to the actual gallons consumed by the new vehicles to determine the savings.

This procedure is complicated by the fact that there is often not a direct one-to-one replacement of vehicles. As a solution, draw as small a boundary as possible around the vehicles involved in a given set of activities before and after the new vehicle purchase.

Estimating Reductions from Community Programs

For a robust assessment of savings and emissions reduction from a community program you should expect to spend a significant amount on evaluation. These types of evaluations are typically performed by third party contractors. They rely on advanced survey methods and statistical analysis that are difficult to design and implement, and they are usually only performed to evaluate very large programs that justify the expense. If your program is part of a larger State- or utility-sponsored program there may be opportunities to contribute to the evaluation of those larger programs with local data. Generalized guidance is provided below.

Programs for Appliance and Equipment Replacement and Weatherization

These programs usually take the form of rebates or other incentives for new appliances that meet Energy Star or another energy efficiency standard, with the old appliances being collected and recycled to remove them from use. Compact fluorescent light-bulb giveaways are an example. Effective evaluation of the program requires not only information about the equipment, but also predicting what the people participating would have done in the absence of the program. There are a couple important factors to consider in evaluating the impact of a program:

1. Net to Gross ratio. The number of actual equipment changes *caused* by the program is not necessarily the same as the number of rebates issued or light bulbs handed out. The factors that can affect this are:
    a. Any old units that are not retired
    b. People who would have changed to the more efficient equipment anyway without the program
    c. Attrition: people who switch back to the less efficient option (for example, they don't like the light quality from the fluorescent bulb).
    d. Spillover effects: people who don't participate in the program, but are inspired by it to switch to the more efficient option.
2. Useful life. There are two factors that should be accounted for related to the useful life of equipment. First, the new equipment distributed will eventually wear out or lose its efficacy. Second, the old equipment replaced would have worn out and been replaced eventually anyway, in most cases with something of similar efficiency to the new equipment under the program. Useful lives are used in calculate the cost-benefit of a program, and in long-term climate action planning.

In the absence of a thorough survey-based program assessment, a listing of net-to-gross ratios and useful life figures can be found in the California Public Utilities Commission's Energy Efficiency Policy Manual, Version 1, October 2001. These can be helpful to get an idea of the impact of your program

Renewable Energy
Evaluating emissions reduction from renewable energy is usually a straightforward process, because the energy produced is almost always metered. In this case, simply multiply the energy produced by the grid average emissions factor. The same method applies to purchases of renewable energy credits.

Transportation Programs
Transportation emissions can be considered the product of vehicle miles traveled, vehicle fuel efficiency, and carbon-intensity of the fuel, as in the following equation.

Emissions = Vehicle-miles-traveled **x** efficiency (mpg) **x** carbon-intensity of fuel

Of these variables, local transportation programs have the greatest effect on vehicle miles travelled. A combination of travel surveys and sophisticated travel models can be used to estimate changes in vehicle miles travelled brought about by local programs, capital investments, or changes in land use regulations. As with community energy programs, you should expect to invest significant resources to make a robust evaluation of emissions reductions from a community transportation program.

Estimating Reductions from Waste Management

Emissions reductions associated with waste disposal are very difficult to estimate with the data that is typically available to a local government. Attempting to model the incremental landfill emissions avoided from diverting organic material from the waste stream with a first order decay model is time consuming and challenging to interpret given the long time periods over which those avoided emissions would have occurred.

Management of waste can affect emissions at different scales and points in the waste "life-cycle." Increased recycling can have very large impacts by reducing the energy consumed to produce goods from raw materials. However, those reductions generally do not affect local emissions in a way that can be traced back to the waste management option selected. Likewise, composting can have large impacts from reduced water and fertilizer consumption that results from use of the finished compost. Again, these impacts usually will not be reflected in local emissions levels. That is not to say that these reductions are not real; the emissions benefits of recycling and composting can be calculated and celebrated as part of the community's contribution to reducing emissions globally, but will contribute little to meeting local emissions reduction goals.

The documentation from the USEPA Waste Reduction Model (WARM) can provide a good source of information for performing calculations of waste-related emissions reductions. While WARM is a convenient and useful tool, the outputs generated by the software do not allow the user to disaggregate reductions of landfill methane impacts from the other kinds of emissions impacts described in the previous paragraph. Performing your own calculations with factors from the WARM model documentation allows focusing on just the landfill methane impacts. These values can be used to calculate the emissions reductions associated with diverting organic materials from your waste stream in a way that is consistent with those waste emissions accounted for in your greenhouse gas inventory. Table 6 contains factors from the WARM model documentation on the ultimate generation of landfill emissions for various waste categories.

Table 6: Landfill Methane Emissions from Various Material Types (MTCO2e/Short Ton)

Material	Landfills Without LFG Recovery	Landfills with LFG and Flaring	Landfills with LFG and Electricity Generation
Food Scraps	1.47	0.5	0.37
Yard Trimmings	0.79	0.34	0.29
Grass	0.72	0.37	0.33
Leaves	0.56	0.21	0.17
Branches	1.17	0.12	-0.02
Corrugated Containers	2.27	0.25	-0.01
Magazines/Third Class Mail	0.92	0.12	0.02
Newspaper	0.81	0.11	0.02
Office Paper	3.83	0.48	0.05
Phone Books	0.81	0.11	0.02
Text Books	3.83	0.48	0.05
Mixed Paper	2.12	0.25	0.01

* Reproduced from USEPA Model Documentation, Organics Chapter Exhibit 13 and Paper Products Chapter, Exhibit 28[2].

For those looking to promote the wider benefits of recycling and composting activities beyond direct landfill emissions, the State of California Air Resources Board has recently published a set of emissions factors that are calibrated to better reflect those outcomes from what occurs in the state than national average factors.

Recycling Emissions Reduction Factors:
http:/www.arb.ca.gov/cc/protocols/localgov/pubs/recycling_method.pdf

Composting Emissions Reduction Factors:
http://www.arb.ca.gov/cc/protocols/localgov/pubs/compost_method.pdf

[2] http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

Planning for Quantification of Reductions

Efforts to measure emissions reduction from implemented projects are often hampered by a lack of data availability. Planning for quantification before implementing the measure makes it much easier to collect the needed data. Additionally, it is common practice when an outside contractor implements an action that the contractor also performs an evaluation of the impact of the measure. However, this is often provided to local governments only as a final number without explanation of methodology or source data. This limits the local government's ability to evaluate the robustness of the reduction number, or to calculate using a different methodology if desired. Contracts and requests for proposals should ideally specify what data on project performance will be collected, the evaluation methodology, and that all original data will be provided to the local government.

As you plan for implementation of a project, consider the following questions to help you prepare for effective quantification of project impacts:

- Which of the above described methodologies is most appropriate for this project? What data is needed to effectively implement that methodology?
- Will additional sub-metering or other monitoring equipment allow more effective evaluation of performance?
- Is needed data recorded and stored in a way that is easily retrievable and in the form and degree of resolution needed?
- If it is a project involving third parties or community-level energy use, are waivers needed to have access to relevant data?
- What portion of the project budget needs to be allocated to measurement and verification?

Setting up systems to monitor data may involve software packages, or may be as simple as setting up an Excel spreadsheet and designating someone to update it on a monthly basis.

3. Understanding Changes to the Inventory

Previous sections have described the process for conducting re-inventories as well as measuring GHG emission reductions from individual mitigation measures. As a local government conducts a re-inventory to evaluate its overall progress towards its GHG reduction target, the impacts of individual GHG mitigation measures are expected to be seen in re-inventory. However, in addition to GHG mitigation measures, multiple other factors are responsible for changes in a community's emissions, such as population growth or decline, economic growth or decline, technological improvements from regulatory drivers, or local weather conditions. While some external factors may result in emission reductions (e.g. economic decline, or technological improvements), others may lead to emission increases (e.g. population growth, or economic growth). Moreover, both positive and negative factors can simultaneously be at play in a community (for example, a community's population may have increased, but the carbon intensity of its emissions may have decreased because of favorable weather, and the result might be a net reduction in emissions). Subsequent inventories after the baseline should include an analysis of external factors causing changes in emissions in addition to analyses of emission reductions that occurred from specific GHG mitigation measures.

At the national scale, top-down analytical methods have been employed to identify factors contributing to changes in emissions, such as the Decomposition Analysis Method. The Decomposition Analysis Method is primarily used to understand changes in emissions from energy consumption, and assumes that emissions are influenced by changes in population, economic growth, the energy intensity of economic growth, and the GHG intensity of energy consumption. According to this method, GHG emissions can be explained by the following equation:

GHG emissions from energy = GHG emissions per unit of fossil fuel consumed
× fossil fuel consumed per unit of energy consumed
× energy consumed per unit of GDP
× GDP per capita
× population

While this method and its adaptations have been widely adopted by nations to explain changes in emissions at the national scale, local governments often lack the capacity to conduct the needed complex statistical analyses due to budgetary constraints or lack of data availability. Nonetheless, local governments can employ simple comparisons of site-specific data on population changes, economic conditions, weather conditions, emission sources/sectors, energy consumption, and carbon intensity of fuels to pinpoint the main determinants of changes in emissions.

The first step in identifying external factors and their impacts at the local community scale is to compare the overall emission changes seen in a community's re-inventory with the emission reductions from individual GHG mitigation measures implemented in the community. If the community hasn't yet implemented mitigation measures, then any changes in emissions can entirely be explained by external factors.

However, for communities that have implemented GHG mitigation measures, any discrepancies found between emission reductions from measures and the overall re-inventory indicate that external factors are impacting the community's overall emissions.

Scenarios of External Factors

There are 4 different scenarios for how a decrease in GHG emissions from one year to the next can be explained

a) A community has not implemented any mitigation measures, but external factors have caused its emissions to decrease (e.g. economic decline). Figure 5 illustrates this graphically.
b) A community has implemented mitigation measures, and no external factors have significantly impacted emissions (though this scenario is fairly unlikely). (see Figure 6)
c) A community has implemented mitigation measures, and additionally, external factors have also caused its emissions to decrease (e.g. lower carbon intensity of energy consumption because of hydro-power generation), thereby amplifying the emission reductions. (see Figure 7)
d) External factors have caused an increase in the community's emissions, but this increase has been offset by emission reductions from mitigation measures implemented in the community. (see Figure 8)

Similarly, there are 2 different scenarios for how an increase in GHG emissions can be explained from one year to another

e) A community has not implemented any mitigation measures, and external factors have caused an increase in emissions (e.g. population growth). (see Figure 9)
f) A community has implemented some mitigation measures, but they are offset by an increase in emissions caused by external factors. (see Figure 10)

Lastly, two possible scenarios can explain why community's emissions may remain somewhat constant

g) The external factors causing an increase in emissions have been negated by mitigation measures. (see Figure 11)
h) There has been no discernable impact of external factors on the community and no mitigation measures have been implemented. (see Figure 12)

Figure 5

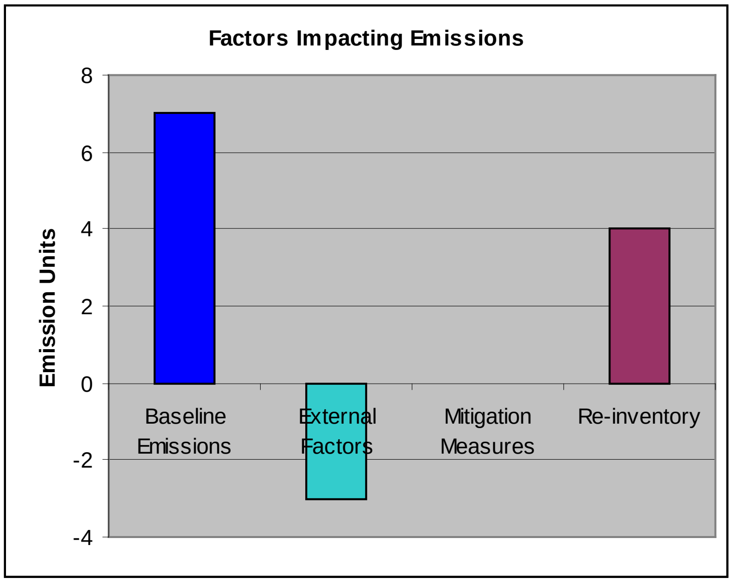


Figure 6

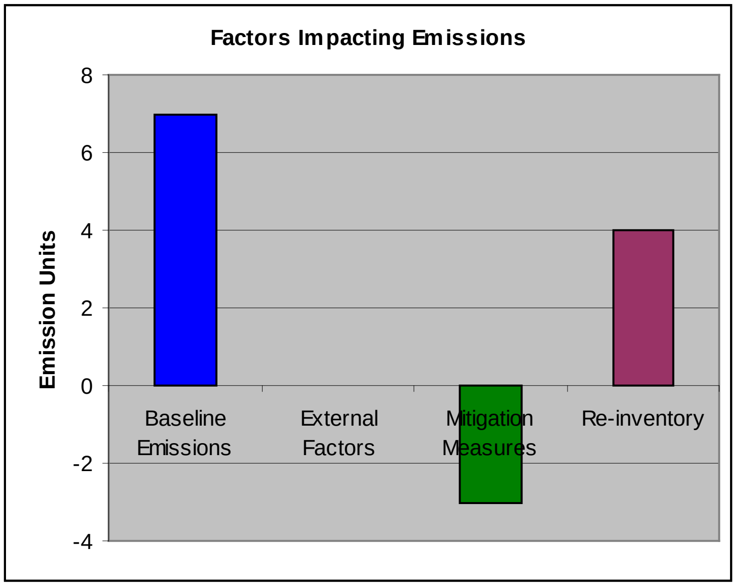


Figure 7

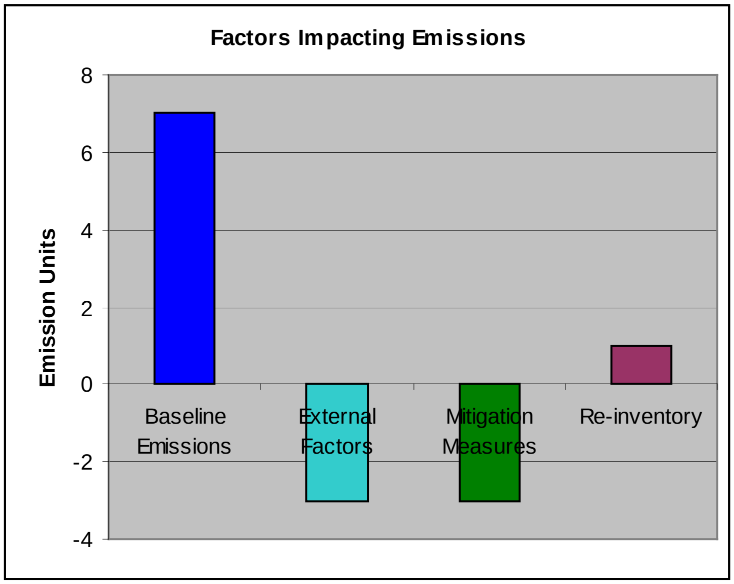


Figure 8

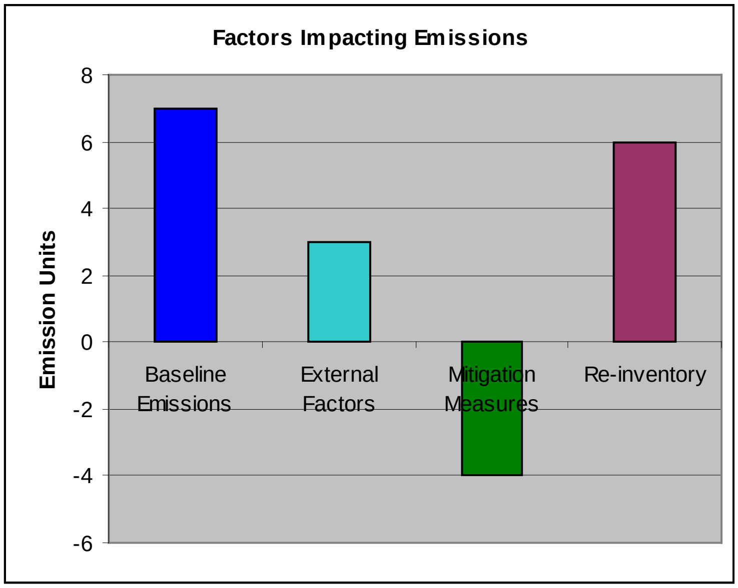


Figure 9

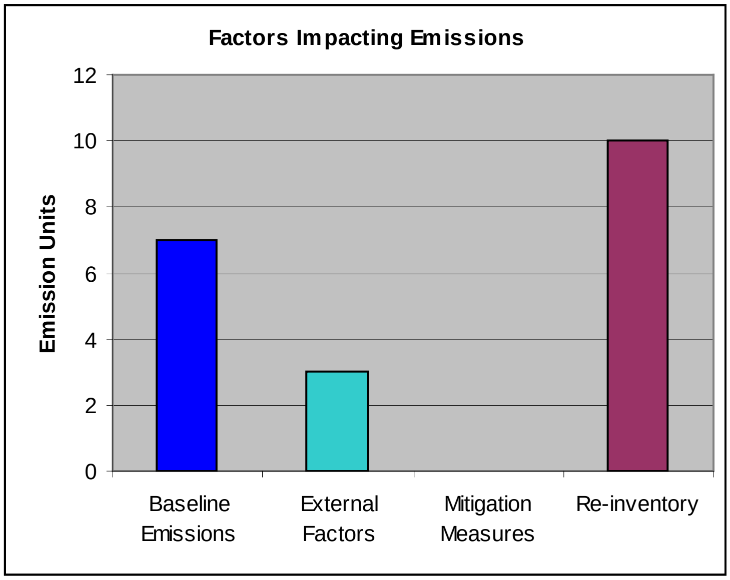


Figure 10

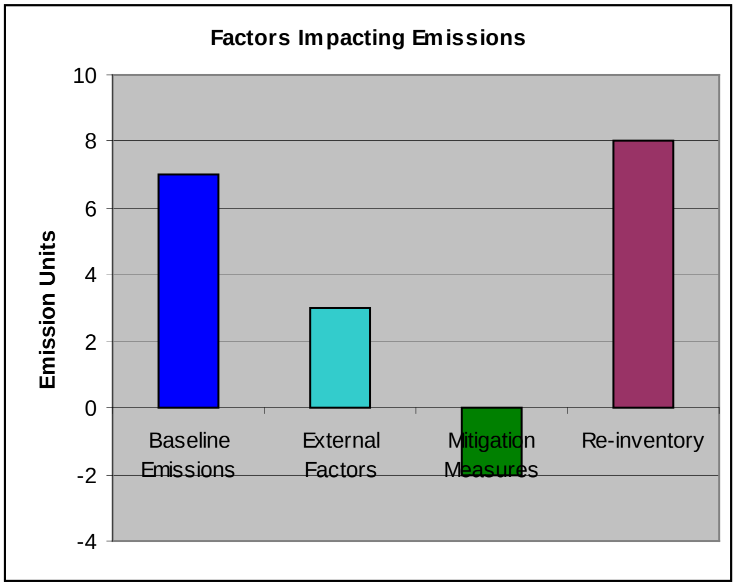


Figure 11

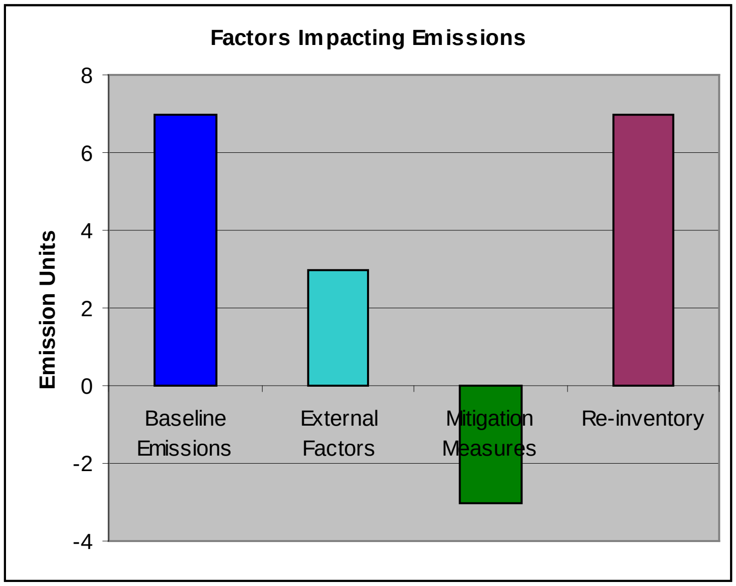
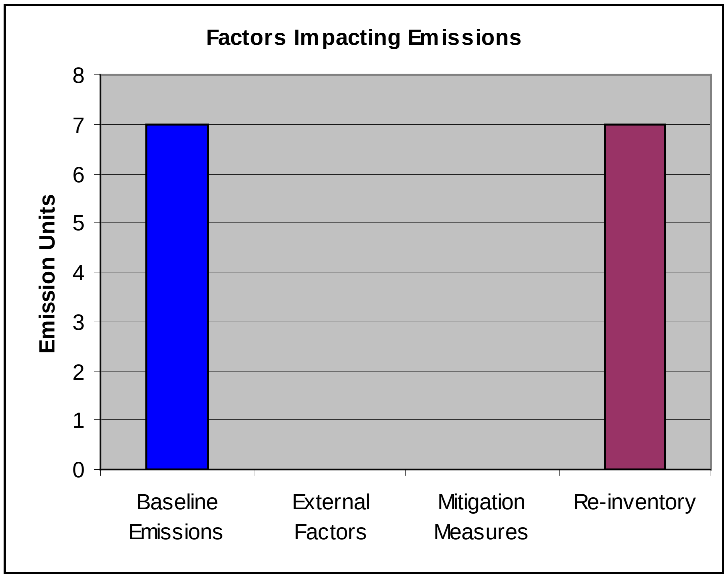


Figure 12



Once it is determined which of the above scenarios is applicable to the community that has done the re-inventory, emissions in the various sectors of the community's baseline as well as subsequent re-inventory should be compared (i.e. residential, commercial, industrial, transportation, and waste sectors). For example, a community may see an increase in residential emissions, but a decrease in industrial emissions. Analyzing changes in emissions by sector can provide initial clues about the drivers of those changes. For example, a decrease in industrial emissions could be due to the shutdown of large industrial point-sources. On the other hand, an increase in waste-related emissions (solid waste and wastewater) could be due to population growth. Caution should be exercised while making such inferences. The interplay of external factors affecting emissions is complex, and multiple external factors may cause changes in emissions. Undertaking this initial evaluation, however, will provide a starting point for identifying the external factors at play in emissions trends.

Background Data Metrics

In order to avoid incorrect interpretation of data, it is essential to not only look at the emission outputs, but also the background data behind the emissions outputs in each sector. The following background data metrics should be compared across the board from one year to another:

- Total kWh of Electricity consumed
- Total therms of Natural Gas Consumed (or quantity of any other fuel type consumed)
- Emission Factors of Electricity
- Vehicle Miles Traveled
- Vehicle Types and Fuel Efficiencies
- Quantity of Waste Generated
- Quantity of Water Consumed (or Quantity of wastewater generated)
- Heating Degree Days or Cooling Degree Days

- Economic indicators like Number of Jobs, Unemployment, Commercial Floor Space, and Housing growth

It is the changes in these metrics that impact emissions, and several factors are responsible for changes to these metrics. Some of these factors are described below.

External Factors Causing Changes in Background Metrics

Changes in Population

According to the California Department of Finance, California's population is projected to exceed 50 million by 2032, and reach almost 60 million by 2050. Much of this population growth will take place in California's metropolitan areas. While population growth is typically gradual over a period of time, some communities can also grow larger in size over a short period of time because of changes in their geographic boundaries (for example, annexation of previously unincorporated territories).

Local governments conducting re-inventories should examine how their population has changed since the baseline year. Typically, population growth is usually responsible for a proportional increase in water consumption, wastewater generation, and solid waste generation, which in turn lead to higher emissions. For those sectors, a comparison of emissions per capita from the baseline and subsequent inventories can provide an explanation of whether population growth is the primary factor contributing to the increase in emissions. If the per-capita emissions for those sectors have not changed over the two years, then it may be reasonable to assume that changes in emissions are proportional to the changes in population.

The relationship between population growth and energy consumption may not be as linear, because it is complicated by other factors like density, standards of living and efficiency. Under business-as-usual conditions, and in the absence of mitigation measures aimed at improving energy efficiency or density, the energy consumption of a community both in the built environment and mobile sector buildings and transportation would rise in conjunction with population growth. However, before attributing changes in energy consumption solely to population growth, other external factors should be examined.

Accounting for Effects of Weather

Changes in weather conditions can affect greenhouse gas emissions in two ways:

a) Weather conditions directly impact energy consumption (e.g. hotter summers or colder winters would lead to higher energy consumption for cooling and heating respectively).
b) Weather conditions directly impact the production of clean energy.

If weather conditions in a community's re-inventory year are very different from those in the baseline year, then the heating degree days and cooling degree days for the two years can be used to determine the extent to which a change energy consumption is the result of weather. Heating and cooling degree days measure the difference between the average outside temperature each day and the temperature set point of buildings. If the increase (or decrease) in energy consumption is proportionate to the changes in heating/cooling degree days, then it would be reasonable to assume that weather conditions are responsible for the change in emissions from the residential and commercial sectors.

Weather conditions can also have a direct impact on carbon intensity and emissions from electricity production, because many renewable sources of electricity are weather-dependent (e.g. solar, wind, and hydro). Utilities typically use a mix of fossil fuels and renewable fuels for electricity generation, and this fuel mix changes every year. For example, in years of drought, the contribution of hydropower to electricity production decreases, and may be substituted by fossil fuels. As a result, the GHG emissions per unit of electricity produced increase in years of drought. In fact, the GHG intensity of electricity can even change (albeit less significantly) based on variability in electricity demand due to weather. Peak demand for electricity is generally met by fossil fuels, which raises the GHG intensity of total electricity production.

Utilities report the GHG intensity of their electricity production in the form of emission factors. Local governments should compare how these emission factors have changed from their baseline year to their re-inventory year. If the emission factors have increased in the re-inventory year, this would result in an increase in emissions even if the energy consumption in the residential, commercial, and industrial sectors has remained constant. Emission factors reported by various utilities in California can be found in the Local Government Operations (LGO) Protocol. For communities served by smaller power suppliers that may not have calculated site-specific emission factors, State averages can be used (they are also listed in the LGO Protocol). Some utilities offer additional guidance on interpreting emission factors. For example, PG&E has made an information sheet on emission factors available to its customers, which provides guidance on how emission factors should be used to conduct inventories as well as monitor progress towards GHG emission reductions.

Accounting for Effects of Technology or Regulatory Change—Transportation Sector

In 2007, ARB adopted the Pavley I clean-car standards to reduce GHG emissions from new passenger vehicles from 2009 through 2016. However, the impact of these standards in reducing greenhouse gas emissions depends on the uptake of newer, more fuel efficient vehicles, and the retirement of older vehicles in a community. In order to understand the impacts of Pavley I on GHG emissions, local governments would have to compare data for both the baseline year and the re-inventory year on the breakdown of vehicle types in their community, the make/model year of the vehicles, the miles traveled by those vehicle types, the fuel efficiencies of the vehicles, and the GHG emission factors of the vehicles. The data on vehicle miles traveled can be obtained from the Metropolitan Planning Organizations (MPOs) serving communities or the Highway Performance Monitoring System (HPMS) data library. The data on vehicle characteristics and emissions factors is provided by the California Air Resources Board's EMFAC2011 Model at the County level, and currently, it is not available at the individual community level, unless a site-specific transportation sector analysis is conducted. The lack of data availability presents a difficulty in calculating the actual emission reductions caused by this State policy driver.

However, there are alternative methods for estimating the net impacts of Pavley standards on GHG emissions. The SEEC Forecast Assistant describes a methodology for estimating the average improved fuel efficiencies of new passenger cars based on the impact of the 2012-2016 CAFE standard. Under this methodology, the estimates of percentage increases in fuel economy by calendar year were derived from the Optimization Model for Reducing Emissions of Greenhouse Gases from Automobiles (OMEGA) output "Benefits Calculations.xls" file that was used in the analysis to support the Model Year 2012-2016 Light Duty Greenhouse Gas Rulemaking. While this analysis was performed at the national scale, it is believed to be the best available resource for use in the State of California.

The fuel efficiency improvements derived from this method can be applied to the emissions outputs calculated in the re-inventory year. The difference between the emissions in the baseline and re-inventory years would provide an estimate of the impact of Pavley I on the community's emissions.

Accounting for Effects of Technology or Regulatory Change—Electricity Generation

Established in 2002, accelerated in 2006, and expanded in 2011, California's Renewable Portfolio Standard (RPS) is one of the most ambitious renewable energy standards in the country. The RPS program requires investor-owned utilities, electric service providers, and community choice aggregators to increase procurement from eligible renewable energy resources to 33% of total procurement by 2020. As electricity suppliers make progress towards achieving this target, the impacts of their progress will be reflected in their reported emission factors for subsequent years. In order to quantify the impacts of the RPS on their emissions, local governments should examine how their emission factors have changed in the baseline and inventory years. Lower emission factors indicate a higher percentage of renewable source fuels.

Accounting for Effects of Economic Growth or Decline

In light of the recent economic downturn, it is important to understand how GHG emissions might be affected by economic conditions. Indicators such as job growth rates, unemployment rates, commercial floor space, and residential floor space provide insights on the state of the economy. Studies by the California Energy Commission, show that commercial floor space and the number of jobs have closely correlated with the growth in energy consumption in the commercial sector. The changes in number of jobs and commercial office space can be compared between the baseline and inventory years. If those changes are proportional to the changes seen in commercial or residential sector emissions for the two years, it is possible that economic conditions are responsible for those changes.

Some changes in local economic conditions may be quite obvious, such as the shutdown or addition of a large industrial point-source of emissions (e.g. a manufacturing plant). Such changes can significantly affect emissions in the commercial/industrial sector. If the local government has information on the status of new and existing industries and local businesses in their community for the baseline and re-inventory years, this information can be compared against the emissions from the commercial/industrial sectors and a relationship can be established between the two.

Economic conditions can also affect emissions in the transportation sector. Individuals in a community respond to price signals and financial constraints and may drive less under financial constraints or if fuel prices rise. However, capturing this data at the community scale is challenging for the reasons discussed in the transportation section above.

4. Using the Information to Update Action Plans and Implementation

Completing a re-inventory and analysis of emissions reductions from individual measures is a major accomplishment that a small but growing group of local governments have achieved. However, these activities are not worth the investment if they are not used to inform a new evaluation of the emissions reduction target and climate action plan from Milestones 2 and 3. You will want to consider:

- Are you on track to reach your target?
- Are changes needed to your action plan?
  - Are there particular sectors where emissions are growing or not reducing sufficiently, that need additional action?
  - Are individual projects performing as expected? Do changes need to be made to increase effectiveness? Should resources be re-allocated from under-performing projects to particularly effective ones?
- Does the reduction target need to be revised?

Your Milestone 5 report should include a comparison of your measured emissions reduction to the linear reduction needed to reach you goal. Use the analysis conducted in Section 3 to inform whether you can expect to continue progress toward your goal.

Many local governments have set ambitious reduction targets, motivated by scientific evidence of the dramatic emissions reductions needed to stabilize the climate. There are many things that local governments can control or influence to reduce emissions in their communities; these include land use patterns, building codes, and incentives or recognition to encourage energy efficiency by businesses and residents. However, there are also many things that local governments cannot control. Unless they own a municipal utility they have little or no control over the fuels used to generate electricity for their community. They have no control over the fuel efficiency of vehicles. In addition, fast-growing communities may find that despite making significant reductions in per-capita emissions, overall emissions have increased. Because of these areas where they cannot control, many local governments that have made serious and significant efforts to reduce emissions have been unable to meet their goals. The current financial challenges facing local governments add additional obstacles to meeting emissions goals. It is important to be realistic that meeting ambitious emissions reduction goals is hard, and to celebrate what has been achieved, while also looking for ways to further reduce emissions.

The completion of Milestone 5 is a valuable opportunity to communicate with your community and stakeholders about your successes, and to build further momentum and support. Be sure to highlight the emissions reductions received and the most successful projects. Also, highlight co-benefits of emissions reduction actions, including cost savings, jobs created, and benefits to public health or quality of life. Include specific stories to make the information approachable; for example, you might talk about how one homeowner participated in a weatherization program or how a particular bike path has benefited those who live near it. ICLEI's Outreach and Engagement Guide can help you tailor your message to resonate with the various audiences you want to reach.

The completion of Milestone 5 is also an opportunity to talk to your stakeholders about new or expanded programs to achieve additional emissions reductions. You could include recommendations for changes to the action plan as part of the progress report, or you could use the release of the progress report to launch a broader community and stakeholder engagement process to update the action plan. Look to the Quick

Start Guide for Climate Action Planning, as well as ICLEI's Sustainability Planning Toolkit and Outreach and Engagement Guide to help you shape this process.